

GEOMAGNETIC STORM AND IT'S EFFECTS ON FINANCIAL MARKET

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ABSTRACT

In modern finance the most difficult job is to explain the movement of everyday capital prices. This paper throws a light on enlightens the investors how geomagnetic storms impact daily returns of capital market, deviations in the average returns and change in investor's strategies. Many researcher's study establishes the fact that there is impact on the mood of the investors by the effect of geomagnetic storms which in turn, investors mood are related to behavior of the human, decisions and their judgments. This paper also reveals that investors repeatedly feature their emotions and feelings to an unpredictable cause, which leads to erroneous conclusions which are exaggerated by the effect of geomagnetic storms, which leads to sell them more capital on these violent days because they wrongly feature their worse mood to unconstructive economic prediction as compare to awful environmental conditions. The main principle of this manuscript is to recognize the misattribution of pessimistic choices of assets in capital market and moods, which ultimately affect the capital market return due to behavioral factors and bad environment conditions which is directly affected by geomagnetic storms.

KEYWORDS: Behavioral Finance, Geomagnetic Storms, Capital Returns and Misattribution of Moods

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INTRODUCTION

Meaning of Geomagnetic Storms (GMS)

The geomagnetic storm (GMS) which gives rise to beautiful Northern lights is a short lived disturbance in the earth's upper atmosphere or earth's magnetosphere. It is caused by solar flares or solar winds that is intense explosion from originating the visible segment of the sun's chromospheres which disturbs magnetic field. These solar flares are known as plasma which is made up of electrons and protons with the energy of earth of some thousands electron volts. The substances which are come from these flares move through the interplanetary medium. The speed of these flares is ranging from 1,000 to 2,000 km per second, and the expelled substances approaches the earth surface in approximately 21 hours. The force of plasma is spread to the upper circumference of magnetosphere of earth which causes the changes earths in geomagnetic field. The large geomagnetic storms occur when the direction of these charismatic fields surrounded by the planetary wind is directly contradictory to the earth's charismatic field. On a regular basis sun produces "bubbles" (coronal mass ejections) the speed of these bubbles is very fast. These bubbles are denser than regular ones and hold elevated charismatic fields. The movement of these type of bubbles is far away from the sun at a speed around Two million miles per hour. When bubbles start from the sun to arrive at earth, the distance travels by them are Ninety Three million mile in around forty hours. Since sunspot activity occurs in around eleven years, so geomagnetic storm displays some cycle as well.

Disturbance – Storm Time (DST) is the index which tells about the changes in the geomagnetic storm. The Disturbance Storm Time index calculates approximately the worldwide average modification in the horizontal module of Earth's charismatic field at the equator and the measurements are done from different magnetometer stations. Disturbance Storm Time is calculated in every one hour and its description is given in close to real time. During normal days, Disturbance Storm Time is between plus twenty and minus twenty nanotelsa (nT).

Geomagnetic storm can also generate a serious danger for satellites such as for commercial and armed forces operators, supremacy companies, and astronauts, due to effect of it the existence of oil pipe lines also become shorter. The most important thing is that, geomagnetic storm causes a serious hazard for human beings regarding their health. From last ten years, in many countries, such as Russia and in European countries, standard warning regarding the occurrence of geomagnetic storms have been matter from past ten years. In a most recent research, geomagnetic storms and its effect was found in many other countries such as the U.S, U.K, and Japan. Nowadays, we can gather regular information on the occurrence of the geomagnetic storm movement from various channels. Geomagnetic storms have great effect on the health and behavior of humans, which directly motivates the study of a possible link between the capital market and geomagnetic storms. In this research paper, we recommend a possible and economically practical approach links related to returns from capital market and geomagnetic storms and also present experimental evidence.

OBJECTIVES

- To determine how Geomagnetic Storms impact every day returns of capital market, deviations in the average returns, and change in investor's strategies.
- To determine the effect of geomagnetic storms on people's moods while relating to the decisions, opinions and behavior of the people.

METHODOLOGY

- We have taken into consideration the indices of US capital market which is applied by eminent researchers and the NASDAQ, the Amex, the S&P 500, and the NYSE are 4 US indices.
- We collect the data from the NASDAQ, the Amex, the S&P 500, and the NYSE size deciles from CRSP, to study the consequences of Geomagnetic Storms (GMS) on small cap versus large cap capitals.

Phases of Geomagnetic Storm

The phases of geomagnetic storm are divided into three parts which tells about how geomagnetic storm occurs from initial phase to recovery phase, which are as follows:

- **Initial Phase:** In the initial phase of geomagnetic storm, it is illustrated by DISTURBANCE STORM TIME or SYM-H, which is a one minute component, increased by twenty to fifty NT (in tens of minutes). Most of the geomagnetic storm does not have an initial phased and there is no unexpected increase in DISTURBANCE STORM TIME or SYM-H is follow by a geomagnetic storms. The initial phase of geomagnetic storms is also known as Storm Sudden Commencement (SSC). This phase is connected by means of density of the magnetosphere, which results in an enhance in local strength. The period of this phase can be up to 2-8 hours.

- **Main Phase:** The period of main phase of geomagnetic storm is about 12 to 24 hours. The main phase is about decreases in surrounding field intensities. In this phase, geomagnetic storm is characterized in terms of DISTURBANCE STORM TIME, typically less than -50 NT. Typically, the lower bound of values during the course of storm is said to be in the range of -50 and -600 NT.
- **Recovery Phase:** This phase ranges from 10 hours to as much as 7 days. This phase results from reconciliation between the lower and bound and normal range of storm time.

Types of Geomagnetic Storms

We generally talk about geomagnetic storms as being classified into two major categories, namely, recurrent and non-recurrent storms. The detailed explanation is as follows:

- **Recurrent Storms:** The periodicity in storms has a time period of 27 days. These types of storms are typically seen in declining cycle of solar cycle. In the interplanetary medium and specifically at the juncture of low- and high-speed solar winds streams in the vicinity of the Sun, high-pressure magnetic fields are generated. Recurrent storms are formed when the Earth is exposed to these magnetic fields.
- **Non-Recurrent Storms:** These storms are typically seen when solar phase is at its peak. Interplanetary disturbances due to coronal mass ejections (CMEs) are the source of non-recurrent storms.

Causes of Geomagnetic Storm

As discussed above, when there is change in the properties of solar wind, they produce the magnetic storms. The occurrence of Geomagnetic storms is due to the solar wind which restrains a magnetic field called the interplanetary (IMF) and the direction of it is same as the direction of Earth's field on the dayside. The disturbance of magnetic field occurs when these fields rotate toward an opposed to parallel direction. Usually, the place of IMF is in the ecliptic plane, which is typical is parallel to the Earth's magnetic equator. The exoduses are very small from this average track which causes by revolution of the skewed dipole magnetic field which occurs once in a day and the rotation of the Earth around the Sun is once in a year. When there are changes in the route of the IMF relative to the ecliptic, then it becomes a cause of large departures. These changes are formed by several phenomenons' that initiate from the Sun. The main causes of geomagnetic storm can be explained as follows.

- **Solar Flare:** An unexpected spark of intensity observed over the Sun's exterior or the solar limb, which is interpret as a huge energy released up to 6×10^{25} joules of energy is called as solar flare. They are often in nature and sometimes they are go behind by a colossal coronal mass ejection. It is the most magnificent event which may cause a geomagnetic storm. With the explosion of the solar flare which is present in the radiance of the Sun that discharges a huge quantity of energy in the form of outward-streaming elements. The time taken by these particles to reach earth and there it begins to influence the magnetic field is approximately two days. The particles whose speed is slow discharge earlier in the way of earth.
- **Coronal Holes:** One more incident is accountable for magnetic field, is the survival of coronal holes in the region of the Sun. Coronal holes are the element of the sun corona's and these holes are regularly change their shape because corona is not even. The X-ray images of the sun have been taken in 1970 by the U.S. Skylab astronauts, who found that the corona of the Sun is not only even but also exposed by "holes". Particles break away from

with relatively easier. These particles after coming from corona holes arrived at elevated velocities in their outward expansion in contrast to regular solar wind elements and generate speedy streams. These speedy streams intermingle with the slower-speed solar wind released from areas which are without holes and release the same sloping of the IMF as we have discussed above. Coronal holes continue for much 27-day solar (equatorial) revolution and, as a consequence, produce recurring geomagnetic storms, as we discussed in recurrent storms.

Effect of Geomagnetic Storm

Energy produced by solar flares are very high in nature, which are also very dangerous to living organisms because strong solar flares discharge very high energy elements that produce poisonous emission which is harmful to human health also. Although, the Earth's charismatic field and atmosphere protect the earth's surface from the consequences of solar flares and other solar movements. The most hazardous release from these flares is vigorous charged elements (primarily high-energy **protons**) and **electromagnetic emissions** (primarily **x-rays**). The upper atmosphere of the Earth's surface stopped the flares from x-rays. Although, Earth's surface stopped some flares from x-ray, but then also they do effect the Earth's **ionosphere**, which in turn effect some radio interactions, navigations, damage satellites hardware, electricity grids, pipelines and geologic exploration. The outer atmosphere of earth is heated by the energetic **ultraviolet radiation**, which enhances the friction on Earth-orbiting satellites, which reduces their duration in the orbit. The strong solar flares and radio emissions, both changes in the atmosphere can degrade the accuracy of Global Positioning System (GPS) dimensions.

From the above discussion we can conclude that impact of geomagnetic storm can be divided into following points.

- **Probable Impact**

It refers to that impact which is likely to be happening when geomagnetic storm occurs, but it is not necessary that it affect the following objects. So we can say that probable impact is most likely impact.

- **Induced Currents –:** Irregularities in power system voltage can be possible. On some protection device false alarms may be elicit.
- **Spacecraft:** Automatically surface charging may experience; a large drag on low Earth-orbit satellites and compass reading problems.
- **Routing:** Irregular satellite routing (GPS) troubles, including loss-of-lock there may be enlarged in range error.
- **Radio:** Blinking of High Frequency (HF) radio may be occur.

EARTHQUAKE CONNECTION

Geomagnetic storm has also affected the earthquake. Many strong earthquakes comes just because of solar flares and CMEs which influences the Earth's tectonic plates and release a high energy.

BIOLOGICAL AFFECTS

As we have already discussed geomagnetic storm have affect on humans which is also known as biological effects. In 1998 the study has been conducted and concludes that there is a straight relation between the sun's planetary

storms and living organic effects. The channel which facilitates the solar flares i.e. charged particles from sun to earth surface is the same channel which facilitates to human disturbance. There is present of magnetic elements in both animals and humans about them as similarly present around the earth as a shield.

PSYCHOLOGICAL EFFECT

CMEs are supposed to produce psychological effects in very low magnitude, but nevertheless significant from research perspective. These psychological effects are exemplified by annoyance, palpitations, mood alterations, and a general feeling of being unwell. Some additional psychological effects include cloudy thoughts and confusion. Although these singular and individual psychological states may not be brought to bear on investor decisions, when accumulated, their magnitude reaches a psychological threshold that could be sufficient to affect gross investor decisions. It would be interesting to investigate if the speculated psychological effects are towards the rational side or not.

Geomagnetic Storms (GMS) and Investor's Psychology

There is a growing attention in the enterprise of psychological sciences towards the measurable effect of high intensity of geomagnetic activity and psychological states of those experiencing it. Surely, this area remains under-explored at this point in time and merits attention from both psychologists as well as behavioral economists. For instance, geomagnetic activities have been speculated to be associated with differing mental states of confusion as well higher alert levels - and such mental states certainly contribute to how people process information, evaluate alternatives, and make financial decisions. For instance, one potential way this effect may manifest is as follows: Investors under the influence of geomagnetic storms, if they tend to become distrustful, such a mental state may influence their trading behavior.

Thus we can make a case for a systematic association between GMS and investor behavior. For instance, there are documented cases of returns from investments going down during strong geomagnetic activity. Whether or this association is causal or just correlation-al is contentious. Rigorous experimental designs are required to establish any causal connection between the two.

Moreover, it has also been documented that the relative effects of geomagnetic storm on small capitalization capitals is more in magnitude compared to that on large ones. Interestingly, **Gompers and Metrick (2001)** noticed a marked difference in effects of geomagnetic storms in individual versus institutional investors, in that while influence on individual investors was more, on institutional investors it was relatively less. We can conjecture a hypothesis to explain this: whereas individuals stand to be affected by such emotions as fear, anxiety and greed (which are triggered by geomagnetic storms, as we saw earlier), the institutional investors play mostly by established and time-tested rules, leaving little chance for emotions to come into play.

The gamut of the aforementioned finding concentrates on the idea that GMS have conspicuous influence on evaluation of small cap capitals which in turn influence the ensuing financial decisions of investors.

Geomagnetic Storms and Moods

There is increasing body of work on GMS in themselves. For instance, researchers at UC San Diego (USA) and Nagoya University in Japan have been developing ways to make accurate predictions of GMS between Sun and the Earth. NASA has played its expected role too in it, especially with regard to achieving greater accuracy as regards predictability.

GMS are known to last typically for a couple of days and are generally seen in March-April and September-October period; and the number of storms in a year is generally placed at around 34.

Along the same lines, **Persinger (1987)**, indicate association between GM activity and such psychological states as nervousness, sleeping disorder, distorted moods. As regards depression, it has been documented that GM activity is associated with more than 35% increase in depression **Kay (1994)**. Even more unsettlingly, **Kuleshova et al. (2001)** noticed almost a twofold increase in hospitalization cases due to mental health and cardiovascular problems during GM activity. The risk of myocardial infarction, angina pectoris, disturbances in blood brain blood circulation becomes twofold during GM bouts as against non-GM period. It has also been documented that during the short bouts of GM activity the number of hospitalized cases due to these cases increase from 30 to as much as 80 percent during GMS. According to **Zakharov and Tyrnov (2001)** the origin of the aforementioned psychological effects arise from effects emanating from pineal gland which disturbs the natural circadian rhythm of the body as well as melatonin bio-synthesis. And it is a known fact that abnormal melatonin levels are associated with mood fluctuations. Similar findings have been documented in **Hirshleifer and Shumway (2003)**, **Wright and Bower (1992)**, **Loewenstein (2000)** and **Johnson and Tversky (1983)**.

The aforementioned set of findings reveal the following: incorrect or economically irrational decisions (that violate the Rational Agent Theory in economics) could be associated with an error on the part of people in attributing their emotions – whereas they should attribute their emotions to GM activities, they erroneously attribute them to the information about financial alternatives. Here we propose a model of Individual Investor Financial Decisions based on the findings discussed in this paper.

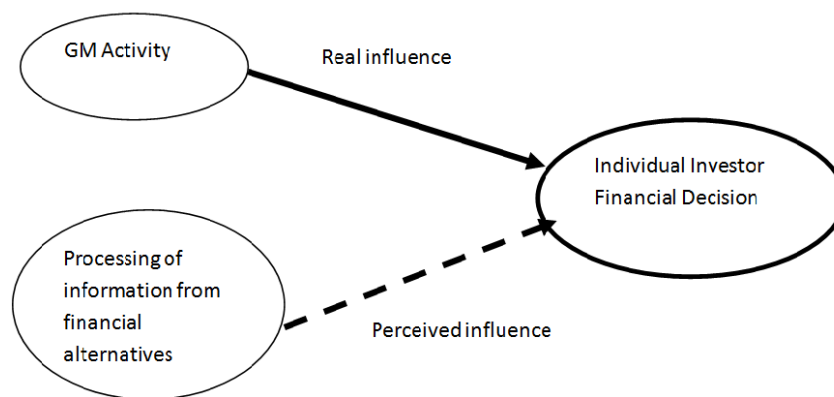


Figure 1: Potential Sources of Psychological States that Can Affect Financial Decisions

Our Proposed Model

The dotted lines indicate the little presence of psychological effects that emanate from information available with individual investors as regards the various financial alternatives available to them – hence we call it the perceived influence, since the influence is not there (or is present in much less degree), and the real influence on psychological states is coming from GM activities, which is therefore indicated with solid line.

Geomagnetic Storm and Capital Market Returns

From the different studies, we can predict that, there is a basic link between the returns from capital market and pattern in geomagnetic activities. Findings relating to medical don't permit us to recognize an exact association between

geomagnetic storm with psychosomatic disorder. According to, **Belisheva et al. (1995)**, **Halberg et al. (2000)**, **Zakharov and Tyrnov (2001)**, the researchers found that in the recovery phase of the storms the effect of geomagnetic activity is abnormally high. So to examine empirically the relationship between returns of capital market at time (t) and Geomagnetic storm pointer at time (t-k), with selection of (k) as provoked factor. As a result, we are taking GMS as a null hypothesis, which has no effect on the capital returns but the alternative hypothesis which is taken as psychological disorders, which brings lesser returns on those days when the effect of geomagnetic activity is very high. From the above discussion we can conclude that, the link between geomagnetic storm and the capital market are not focus on the analysis of data probing.

Why the financial analysts examine a casual relationship among geomagnetic storms and the capital market? The reason behind this, the intensity of geomagnetic storm has insidious effects on human being health and behavior. The researchers have concluded that there is a direct relation between gloominess and nervousness, mood swings and normally great levels of geomagnetic activities. The researchers has also stressed on psychological disarray and fluctuating moods which have been seen to be more observant behavior including judgments related to economic nature and extensive misattribution. So we can say that, the inter relationship between the intensity of geomagnetic storms, mood swings and misattribution affects the return of the capital market. If the investors bend towards more to negative situations through phases of strong geomagnetic activities, the investors will be more bias to trade capitals on violent days. This results due to, investor's characteristic, their worse mood incorrectly and perceived pessimistic economic prospects rather than ecological conditions.

The affects of geomagnetic storm on the market participants is directly which indirectly influence the overall market returns. The demand for riskless assets is quite high due to negative future prediction which ultimately causes the prices of riskier assets to fall or the price will rise very steady. Therefore, the conclusion of this description is a pessimistic fundamental link between pattern in geomagnetic activities and returns from capital market.

While calculating capital market returns we should consider 4 United States index such as the S&P500, NASDAQ, the NYSE, and the Amex. All these indices do not include dividends, as they are value-weighted. US capital markets indices consist of dividends and to analyze we also got qualitatively identical results and these indices are taken from CRSP indices of returns. To investigate small capitalization versus large capitalization capitals due to the effect of geomagnetic storms, we should give an attention on the NASDAQ, the Amex, the S&P 500, and the NYSE size deciles from CRSP

Determine the Effect of Geomagnetic Storms

After a geomagnetic storm, investors not experience good, distrustful and sell capitals due to decrease in the prices and market indexes. The rate of "major" geomagnetic storm may be calculated by the value of Ap^* which recognize periods when Ap exceeds forty.

Ap^* can be said as the most primitive happening utmost twenty four hour value acquired by calculations and eight point successively average of consecutive three hour Ap indices through a geomagnetic storm event without look upon to the starting and ending duration of the UT-day. Ap^* is exceptionally connected with the storm occurrence. In 1974, Allen found that with curiosity the difference between the annually number of magnetic violent days ($Ap \geq 40$) and the normal yearly sunspot number (observe figure for years from 1932-2000).

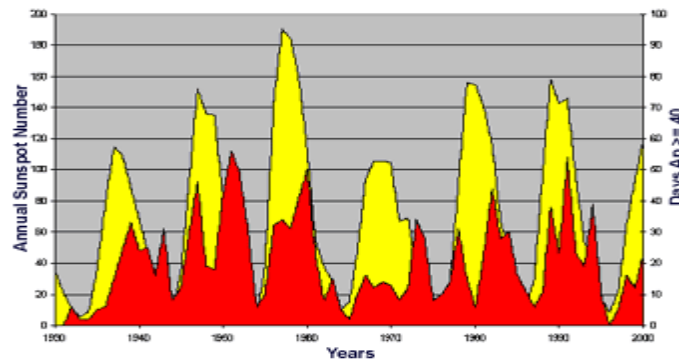


Figure 2: Annual Sunspot Number & Ap Days ≥ 40

Source: <http://www.financialwisdomforum.org/gummy-stuff/magnetics.htm>

The cycle of 11 year is well-known as sunspot numbers (yellow) are logically consistent in shape even though the cycle length and amplitude are varying in maximum. Several have wide, multiyear crest while others are pointed. The pattern of yearly charismatic storm day's (red) is greatly irregular, even though there are some features are constant in it. For example, in each solar year there is one crest in the quantity of charismatic storms which take place throughout the turn down years, and sometimes it is more than one. As per the study, it reveals that counting the available quantity of days in a year comprising daily $Ap \geq 100$, 80, 60 and 40. This attempt discovered the remarkable model which is shown in the above figure, for $Ap \geq 40$, but it also demonstrate the difficulty with the normal Ap index. Ap is the eight value average of only the three hourly ap.

The response of the S&P 500 of the Nov 12, 1960 storm as shown below:

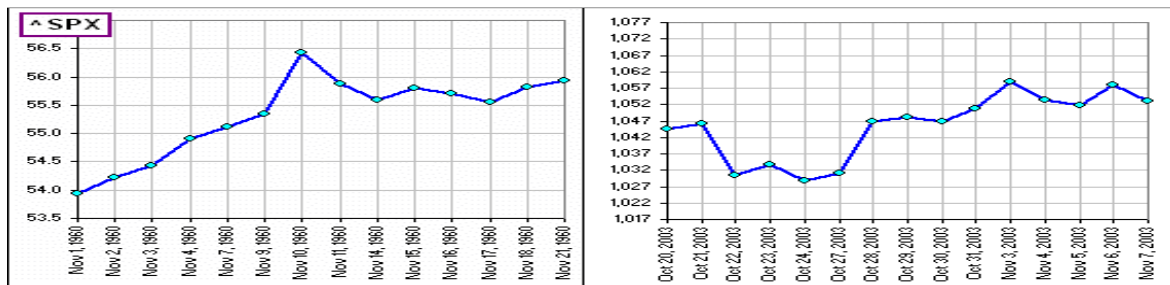


Figure 3

Source: <http://www.financialwisdomforum.org/gummy-stuff/magnetics.htm>

From the above data we can conclude that, from November, 1960 the returns are increasing gradually day by day, on 10 November 1960 the returns are higher. On 12 November 1960, the geomagnetic storm has come and after that there is a tremendous decline in the returns and returns remain low aftermath effect of geomagnetic storm.

After 3 to 4 days of geomagnetic storm effect, the return will increase but on a slow pace as compare to its decline. In the second table, more recent trends are presented.

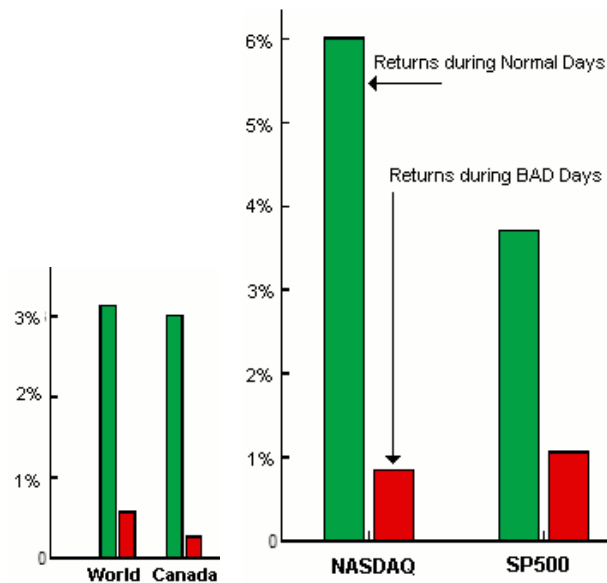


Figure 4

Source: <http://www.financialwisdomforum.org/gummy-stuff/magnetics.htm>

In the above figure, there is comparison of returns of world and Canada, NASDAQ and SP500. The green bar shows the returns during a normal day of trading and red bar shows the return during bad days i.e. aftermath effects of geomagnetic storms. From both graphs, we can conclude that returns decline tremendously after the geomagnetic storm i.e. in normal days of trading the NASDAQ returns is approximately 6% but after geomagnetic storm it decreases which is approximately less than 1%. So there is a big dissimilarity between the returns of normal days and bad days. So we can conclude that, geomagnetic storm has very bad affect on human beings, communications and as well as on the returns of capital markets.

CONCLUSIONS

Above details show that geomagnetic storm effect capital market returns although the environmental factors which persuade the capital market are in control. National and International capital market both are pessimistically exaggerated by geomagnetic storm through recovery phase. We have also documented a more pronounced GMS effect demand for riskless assets, which is quite high due to negative future prediction which ultimately reason the value of uncertain asset to decrease or to climb quickly on a lesser pace. Therefore, the conclusion of this description is a pessimistic fundamental association between composition in Geomagnetic activity and returns from capital market.

This manuscript also shows an effort of ascertain a relation among economics and psychology and also discover the relation among the mood of the investor's and their performance in a financial situation, probably managing for differences among cross country.

The Geomagnetic storms (GMS) have a deep outcome on investor's behavior, human behavior, judgments and decisions about risk. The experimental research done on psychology has recognized a straight link between investor's mood and their decision making. It has been observed that, geomagnetic storms affect the investors and in return they are more prone to dispose their stock on violent days since they erroneously characterize their worse mood to depressing money-making projection as compare to terrible ecological condition. Though it has also been observed that geomagnetic-storms have favorable effect in capital returns. If investors are more positive in the phases of extreme

geomagnetic storms (GMS), investor's might be more prone to dispose stock on violent days. When investors are in worse moods, the judgments and choices made by them are more positive in nature as compare to in good mood. The demand for riskless assets are high by pessimistic investors which in turn affect the price of risky assets to decrease or it may increase the price of less risky assets. The investment decision taken by the individual investors as compare to institutional investors are more influenced by emotion and behavior. The institutional investor's who operate in stock market rebalanced their portfolio with the help specified rules of trading. The effect of Geomagnetic storm (GMS) is more prominent on the pricing of smaller capitalization stocks. **Kamstra, Kramer, and Levi (2003)** studied the Seasonal affective disorders (SAD) and **Saunders (1993), Hirshleifer and Shumway (2003), Goetzmann and Zhu (2003)** studied the sunshine effect which also caused by Geo Magnetic Storms. **Calendar effect and Monday effect also take place because of GSM only.**

Table 1: Arithmetic Mean of capitals effected by GSM

GSM Activity Index	Ap Index GSM
0-29	Silence or Anxious activity
30-49	Minor storm
50-99	Major storm
≥ 100	Harsh storm

The consequence of strong geo magnetic storms in the period of recovery phase not only affect the mood of the investors but it also affect the US capital returns within a seven days when geomagnetic storm hit the atmosphere.

The Geomagnetic Storms Effect on Large Cap Versus Small Cap Stock and their Results

The Geomagnetic storms result is found to be further prominent in the deciding the price of smaller cap stock. When we shift from large capitalization stock to small capitalization stock, the returns of these stocks are generally increased. It is the nature of the individual investor who tries to carry the market portfolio during ordinary days and control his/her savings towards safer asset. If we compare the standard deviation of geomagnetic storm based portfolio with the standard portfolio, which fourteen percent less than the standard portfolio. There is one possible alternative by which investors make some profit during GSM is investing in derivative securities as a hedging tool.

It is also observed that Individual investment is more effected as compared to institutional investment.

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